

GROUND TEMPERATURES COMPARED TO ROOF TEMPERATURES

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To determine what relation, if any, exists between the temperature of the air on the tops of high buildings in the congested sections of large cities and that near the ground out in the suburbs, is the object of the present study, which covers daily records for a period of 10 years, from October 1924 to September 1934.

The observations were taken in Topeka, Kans. The Weather Bureau equipment, used as one station, was located 100 feet above the ground level, on a building in the center of the business section. The second station was over a grass plot in the open, about $1\frac{1}{2}$ miles west of the first. The intervening country is only slightly rolling so that the topography did not affect the readings. The instruments in both cases were housed in standard shelters which, by their louvered sides and double deck roofs, secure both free circulation of the passing air and the exclusion of heat by extraneous radiation, direct or reflected. It should be mentioned here that during the last year and a half of this set of readings the Weather Bureau instruments were about 20 feet lower, owing to moving into the new Federal Building, just across the street from the former location.

The Weather Bureau values of highest and lowest temperature are for the period from midnight to midnight. The ground readings were taken each evening about sunset, after the highest temperature for the day usually had occurred. In this connection one might ask what difference taking one set of readings from midnight to midnight and the other from sunset to sunset could make. There were occasions when the midnight readings on the roof had to be taken as either the maximum or the minimum for the following day. As a rule the same held true for the readings taken at sunset. However, these instances were so evenly divided throughout the period that the error resulting from this discrepancy presumably has not materially affected either the monthly or annual means. For more information in regard to the effect of the time element in the taking of temperature readings, the following papers covering this question will be found very interesting: "The limits of the day as affecting records of minimum temperatures", by E. S. Nichols in MONTHLY WEATHER REVIEW, September 1934; and "The effect of time of observation on mean temperatures", by W. F. Rumbaugh in MONTHLY WEATHER REVIEW, October 1934. In commenting on the two sets of temperature readings herein, one will be designated the ground set and the other the roof set.

The results of the study are shown in the five brief tables herewith.

During the period covering these comparative observations, some of the lowest readings ever recorded in this vicinity occurred, as well as the highest.

By examining the means in table 1, we find that the popular opinion that it is much cooler near the ground is not a fact as far as average temperature is concerned. In this study we find that for the entire period the average temperature at the ground was 56.5° , and 55.8° on the roof. There were individual months when the roof readings exceeded those on the ground; but there was no regularity in their occurrence.

Table 2, mean maximum temperatures, shows that the ground exposure averaged 1.7° above that of the roof for the period.

Table 3, mean minimum temperatures, shows that the ground readings generally were below the roof readings for the period, averaging 0.5° lower.

Table 4, highest readings, shows that these values, like the mean maximum temperatures, varied from one place to the other, but, as a rule, read closely together. This probably is owing to the fact that when the air is warmest it is very thoroughly stirred up. Thus, on August 3, 1930, the readings at the ground and on the roof agreed at 110° . Again, in the year 1934, July 15, the ground reading was 110° and the roof record 111° ; and on August 10 when the ground indicated 111° , it was 112° on the roof.

Table 5, lowest readings, shows the greatest differences, a result due to the more rapid cooling at the ground surface than on the roof of a building. Radiational cooling on the ground is more rapid when the wind movement is light and permits the air mass to become stagnant. Several dates picked at random are here selected to illustrate this: On April 26, 1926, with an average wind movement of less than 6 miles per hour, the minimum on the ground was 37° , 5° lower than on the roof. On September 15, 1928, with an average wind movement of 3.3 miles per hour, the ground temperature registered 54° , and the roof reading was 61° . On November 1, 1929, with less than 5 miles of wind movement, the ground reading was 29° , 5° lower than the roof reading. It will be observed from this that differences of this kind may be obtained at any time of the year. A snow-and-ice cover is another cause of more rapid cooling at the ground surface. During the period January 12 to 16, 1927, several inches of snow accumulated on the ground on the 12th and 13th. Very little remained on the roofs by the evening of the 13th. On the 14th the ground reading was 5° , and the roof 8° . On the 15th the ground read 14° below zero as compared to 9° below zero on the roof. On the 16th the ground minimum was 16° compared to 23° on the roof. Again, consider the period January 22 to 25, 1930: The snow cover had accumulated up to the 22d. On the morning of the 22d there was a ground reading of 19° below zero compared to 13° below zero on the roof. On the 23d the ground reading was 7° below zero, but it was 1° above zero on the roof. On the 24th the record was 9° on the ground, 12° on the roof; and on the 25th, 3° on the ground and 11° on the roof.

The lower night readings on the ground resulted in the daily range of temperature averaging greater at the ground. The largest differences in this connection occurred during quiet spells when the radiation effect was greatest.

SUMMARY OF COMPARATIVE READINGS

[10-year record]

TABLE 1

Stations	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Means:													
Ground.....	31.0	37.8	44.6	57.4	65.5	75.6	81.0	78.1	71.1	57.9	44.5	33.7	56.5
Roof.....	30.1	37.0	43.2	56.1	64.9	75.1	80.5	77.7	70.3	57.6	43.6	32.7	55.8

TABLE 2

Mean maximum:													
Ground.....	41.4	49.5	56.8	69.0	77.3	87.1	92.8	89.8	82.6	69.5	55.7	44.0	68.0
Roof.....	39.6	47.1	53.9	66.6	75.6	85.7	91.3	88.3	81.0	68.0	53.6	41.7	66.1

TABLE 3

Mean minimum:													
Ground.....	20.5	26.0	32.4	45.2	53.7	64.2	69.1	66.3	59.6	46.3	33.3	23.5	45.0
Roof.....	21.2	27.0	32.4	45.6	54.2	64.5	69.9	76.6	59.7	47.2	33.7	23.8	45.5

TABLE 4

Highest temperature:													
Ground.....	71	83	89	93	100	104	110	111	102	93	83	70	111
Roof.....	69	83	88	93	103	105	111	112	102	93	84	70	112

TABLE 5

Lowest temperature:													
Ground.....	-19	-15	0	14	34	46	51	49	35	16	4	-10	-19
Roof.....	-13	-14	4	17	35	49	52	52	38	10	8	-9	-14